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THE TEACHING OF SCIENCE.*

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In suggesting a few of the functions of science teaching I shall not attempt to arrange them in the order of their importance. In fact, the first one I shall mention is the one which probably is least often in our thought—the discovery and training of scientific aptitudes. In a broad sense education is the transmission of the world's knowledge from one generation to another. This rich inheritance cannot be conveyed by libraries and museums or in any mechanical way. It can be handed on unimpaired only by training men capable of receiving and using it. Do the Vanderbilts and the Rothschilds take all possible pains in the technical education of their sons in the management of their vast railway and banking properties? How much more does it concern us to see to the training of the men of science of the future, the heirs of its wealth! Somewhere in our schools today are the Rowlands, the Asa Grays, the Maria Mitchells and the James Halls of the next generation. There, too, are the thousands of the rank and file who are to do their humbler work in winning the scientific victories of the future. It was in an old log school house that the genius of Mendenhall was awakened by a good Quaker lady who had the way of setting her pupils to making simple experiments in physics. Early in the last century an eminent botanist at the University of Cambridge took one of his students into so intimate a friendship that the young man was known among his

*Presidential Address, Department of Science Instruction, National Educational Association, Minneapolis Meeting.

fellows as the one who walks with Professor Henslow. He had been considered a very ordinary boy indeed. His classical schooling, as he himself tells us, had omitted all habits of observation and reasoning. But Henslow discovers the marvelous scientific aptitudes of young Darwin, he secures him place as naturalist on the ship Beagle, and to the friendship of that teacher the great biologist attributes "more influence on his career than any other."

Whether in country school or in college, the teacher who discovers talent to itself, who directs it to its goal and helps it on its way, may be doing his generation a greater service than the munificent endowment which is to deport American students to the ancient University of Oxford.

It may possibly be true that genius does not need to be discovered, that it will blaze forth from beneath any smother of adverse circumstances. Possibly Rowland would yet have been Rowland even if his father had refused to listen to his pathetic cry at classical Andover—"O, take me home!" and had not removed him to the congenial environment of the Rennselaer Polytechnic. But without question the great majority of workers in science owe their efficiency to those whom this department represents. Apart from science instruction their scientific aptitudes would never have come to fruitage. For faculties which in childhood give every promise of large development may be so repressed during adolescence that they are stunted forever. How much science should there be in our schools? Enough so that all the way from primary school to university there shall never be a single year in which the scientific aptitudes of our students may not be developed by the study of nature at first hand.

These boys in our classes who are to be leaders in science are probably not particularly brilliant boys. They may not shine in recitation as do those young intellects which are made with the capacity of the gelatine copying pad and can as faithfully reproduce the phrases of the text. They may ask inconvenient questions; they certainly have a high degree of individual initiative; they may be restive under routine. But in the field and in the laboratory we shall discover in them a marked ability to see, to coördinate and to interpret.

Let me suggest that we enter sympathetically into whatever scientific interests of our boys may at the time be strongest. If they are in the collecting stage, we may gently divert them from postage stamps to flowers or fossils, or butterflies; we may see that the collections are studied with something of the care that Oswald Heer gave his insects, and which made the cabinet of young Spencer Baird the nucleus of the collections of the Smithsonian Institution. It may be that we shall find in our boys a greater liking for their furry and finned and feathered friends alive and at home than dead and on the dissecting table. Then let us see that the laboratory does not repress this normal turning of the young naturalist to out-of-door study.

I do not mean to imply that the cadets of science need be given instruction of a sort different from that of their fellows. The teaching which best brings out scientific aptitudes is only that which every student should have; it is that which performs the second function of science instruction; it brings in touch with Nature. Science teaching is objective, its impressions are at first hand, it brings face to face with facts. How weak and vague, how illusory and fleeting, is the impression of the word compared with that of the thing. It is our peculiar privilege to teach things, not words. In this presence I need not slay again the slain and say aught against the bookish teaching of science. After all it is probably as worth while as the bookish teaching of anything else. I do not know why "Fourteen Weeks" in physics or in geology in the high school is not as valuable as fourteen weeks in Grecian history or political economy. But the text-book teaching of science is so markedly inferior to the laboratory method that it is fast disappearing from our schools. In chemistry, physics, and biology it has well nigh gone. But in the earth sciences the use of new and fruitful methods of study in the laboratory and field has hardly more than begun. How many well equipped physiographic laboratories can any of us count in his own state in colleges and normal schools and universities, to say nothing of high schools? And in how many public schools are such fundamental notions as the weathering of rocks and the work of streams still taught from the printed page, instead of

in the field. Last Fall I asked the students in my different courses in geology in Cornell College how many of them had ever, when in high school or academy, taken an excursion in geography or physiography. And there were only four, out of my one hundred and twenty students, who had ever been taught anything in these two subjects outside the schoolroom. Professor Shaler of Harvard tells of an enthusiastic visitor at the Peabody Museum, who was so anxious to handle the feldspars in one of the cases, because she had been teaching feldspar to her pupils for fourteen years and had never before seen the mineral to know it. Her type, I fear, is not extinct. No matter what or how much we omit from the text, let us teach first and foremost, as critically and as fully as possible, whatever can be seen and handled, drawn and described, and verified by experiment. We may leave to others to teach the conning of the printed page, and the assimilation and the reproduction of its ideas. It rests with us to train the quick eye and the skilful hand, to teach the patient investigation of Nature. I once asked Dr. Alexander Winchell if he found his seniors at the University of Michigan good observers. "Yes," he answered, "if they have not had too much Latin and Greek." Apart from science studies a college course may easily dim the eye and leave one a duller student of things than when he entered. If science is rightly taught in our schools no one need ever say, as the distinguished president of an American university once confessed: "The best teacher I ever had was the kindly old neighborhood loafer, who roamed the woods with me and told me the times of the wild flowers and the habits of the birds."

It is because scientific culture is objective that it has an ethical value wholly different from that of any culture largely subjective, such as literature, art, or philosophy. Edward Everett Hale has told of the good he got when a boy from setting type in his father's office. "The absolute accuracy which is necessary is good for a boy. The solid fact that 144 ems will go in a given space, and will require that space, and that no prayers nor tears, nor hopes nor fears will change that solid fact—this is most important." Here we touch the special function of science training. It teaches limits and bounds, the bounds of the solid fact. In

literary culture the spirit projects itself into the world. It fuses, I might almost say, external reality by the breath of phantasy and reforms it according to its own free creative power. But science faces the spirit with adamantine walls, the unchangeable *moenia mundi*, Its God is the God of things as they are, not of things as we might imagine them to be. Its work is patiently to investigate and humbly to obey. Science, therefore, teaches fairness, emancipation from prejudice and personal bias, and a supreme love of the truth. Its word is not freedom, but law. Everywhere it teaches law, and the inescapable consequences of its breaking.

Despite the rapid upward curve in the scope and effectiveness of science instruction, it was perhaps never more needed than now. We are all of us acquainted with estimable people, cultured and lovely women, graduates of our high schools and colleges, though seldom, I believe, in scientific courses, who have come under the spell of the recrudescence of an ancient delusion. They have been, as they say, "set free." To them there are no solid facts. "Do not teach physiology in the schools for the dear children really haven't any bodies," was the substance of their petition to the school board in one of the largest of the cities of Iowa. It is their faith that they can change at will this old world of ours and annihilate all its cares and pains and disease. I know of nothing which will render our pupils immune to such vagaries except a continuous treatment of physical science administered in large doses. Let me emphasize the fact that because of its touch with external reality, because it teaches the veracity of the world, the discipline of science is preëminently serious, healthful and sane.

All this is intimately related with the last function of science teaching which I shall take time to mention: the discipline of the reason. Language with its vocabularies and paradigms, literature with its imaginative interpretations, with its supreme sense of beauty and of form, rather than of substance and of truth, indispensable as they both are to a liberal education, cannot develop the rational faculty. For this we must ever depend on the strenuous athletics of mathematics and science. What geometry is as an educational instrument in deduction, that the inductive sciences may be made in training the reason to deal

with the concrete facts of daily life. They demand as a daily exercise comparison, judgment, reasoning from cause to effect and from effect to cause, the sifting of evidence, the testing of hypotheses, the calculus of probabilities. If the teachers of America can teach the scientific method to the rising generation, no other war need be made on superstition and credulity. The epoch of patent medicine and the weather prophet will pass to join that of the amulet and the wizard. The rooms of our large hotels will include the "13s," and Friday will no longer be unlucky. Science instruction will have rationalized the social mind.

It was once said by Robert Louis Stevenson—that consummate artist in words—"No one knows better than I that, as we go on in life, we must part from prettiness and the graces." The time has come when in education prettiness and the graces must at least be made subordinate. Secondary and higher education may be likened to the pillars of Solomon's porch. Wrought of solid metal and crowned with chapiters of carven pomegranates and lily work, they were fitly named *Jachin,* He shall Establish, and *Boaz,* In it is Strength. However rich may be the decorative beauty of the education of the future, I believe it will be established in the strength of science. If the understanding is more than the imagination, if truth is more than beauty, science must needs be the central supporting column of all education after the reason has come in its development to surpass the faculties of earlier ripening.

It is the core of science which must save American culture from decadence. There have been, there are, decadent cultures as there are decadent nations. Let me cite the chief historic examples:

The culture of the rhetoricians of Greece, a culture which concerned itself solely with words and the manners of public address, and which at last made the very name of its teachers, the sophists, a byword to future generations.

The culture of the last century of the Roman empire, a culture which devoted itself solely to the study and imitation of models of a literature at that time ancient, and was therefore smitten with barrenness even in the field of letters.

The culture of the English universities within the memory

of men now living, "caravanseries of idlesse," in the phrase of a distinguished graduate of one of them, where the flame of thought was fed with the ashes of ancient studies from which the life had long since been burned out.

The culture of the universities of India today, a culture which the London Spectator recently called "a rotten culture," which teaches the Bengali the masterpieces of English as the Roman was taught the masterpieces of Greek and, "indifferent as it is to science and the constructive arts is ultimately to fall, and probably with a crash."

The culture of China, a culture classical in the veneration of the ancient models of its literature, and exquisite in the cultivation of the amenities of speech, a culture which excluded science from the empire by imperial edict, and which more than any other internal cause is bringing to pass the dissolution of that venerable nation.

The strain of weakness in all these decadent cultures is clear. They make no provision for the education of the rational faculty of man through study of his physical environment. But we need apprehend no similar fate for education in America. It is woven of too many strands. A culture which teaches literature—the highest expression of the thought of the world; history—the social evolution of man; and science—the knowledge of the laws of nature, of self and of society—cannot die except with the death of civilization itself.

THE SCIENCE TEACHER AS A PUBLIC BENEFACTOR.

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It is assumed in this article that the teacher is thoroughly interested in his work, and is master of his subject. For what is more distressing than a half interested, poorly prepared science teacher?

It is true that the teacher of English and history can be of great help to the school literary society. The teacher of language

may get his pupils thoroughly alive to the great problems of literature and philology. The teacher of the commercial branches need not take a back seat when interest is to be aroused. But how much greater is the field of the science department!

In order to be of help to anyone we have to secure their acquaintance and friendship. Mr. E. L. Morris, in the January number of this journal, has a very able article along this line. Our laboratories should always be open to visitors. We should show them around. If possible, have a lung tester, electric pendulum, telegraph system, aquarium and museum always on exhibition. They will go away feeling well repaid for their visit, and, when speaking of the school, they will not forget to mention the laboratory. When a school teacher can get a whole lot of people talking favorably about his work, he has been far from unsuccessful.

If you are teaching in a high school, do not forget the grades. Many a boy or girl has remained in school because he has a desire to study chemistry or botany. If you have a vacant period take some simple piece of apparatus and step into the sixth or seventh grades and explain it to them. Make your explanation short and clear, and they will beg you to come again. They will even repay you by bringing you specimens. Our laboratory is full of rocks, birds' nests, hornets' nests, frogs and even snakes brought in by the grades. Instead of going to the grades yourself, a better plan is to have the teacher come to you and get apparatus. The children will know that it comes from the laboratory and the same result will be obtained, without any embarassment to the teacher as to your superior knowledge. Occasionally put forth your efforts to bring a scientific lecture or entertainment to your town or city. Have liquid air, X-rays or wireless telegraphy been in your town lately? If not, make an effort to secure them. Sell tickets yourself. Get acquainted with the people and let them see that you mean business. You will gain friends and have more influence as a result of your efforts.

Use every opportunity to teach by practical illustration. Take your physics class to the sawmill, electric light plant or telegraph office. With your zoölogy class, visit the meat and fish markets, the zoo or a well-kept sales stable. Get them so interested in their

work that they will pick out every scientific principle as it presents itself to them in their everyday life.

Last, but not least, make yourself a valuable member of society. Teach the minister or lawyer photography. Offer your services and apparatus to the lodge or society that is going to give an entertainment. Be on hand when the football player gets hurt, and apply the principles you teach in physiology. Write an occasional article for the local press upon some current scientific topic. And finally do all these things with as little show and glitter as possible, and you will never have to look for a position.

THE HISTORY OF ZOOLOGY TEACHING IN THE SECONDARY SCHOOLS OF THE UNITED STATES.*

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[A contribution from the Department of Biology, Teachers' College, Columbia University.]

With the dawn of the nineteenth century biology was introduced into the secondary school curricula of the United States. Previous to this time it had held a minor place in European schools, but received no recognition on this side of the Atlantic. Its introduction into America is to be attributed to the broadening conception of the meaning and function of education which prevailed in the country after the Revolution and which expressed itself institutionally in the founding of academies, more liberal in both aim and subject matter than the earlier grammar schools had been. The introduction of biology cannot be connected directly with the founding of these academies except in so far as both are the result of one cause; for during the first quarter of the century it was confined within the limits of female seminaries and "to classes collected especially for hearing lectures on that subject." Even in these places botany alone was taught, being regarded as preferable to zoölogy by reason of its being "more attractive, elegant and precise, so well adapted to the refinement of female education." The precedence thus gained by botany over zoölogy it has maintained to the present day.

*Essay presented for the degree of Master of Arts, Columbia University, 1901.

About 1825 zoölogy first made its way into the curriculum. In aim, subject and method it resembled but slightly the zoölogy of the present. Its intrinsic value in broadening and training the mind was no part of the purpose of its introduction, but rather to acquaint children with the works of the Creator and inspire them with love and admiration for a Being who could and did create such great and wonderful things for the children of men. All sciences were taught more or less with this end in view, but none, perhaps, unless it be astronomy, was calculated so effectually to accomplish the purpose as biology. Just here may be noted again the unity of purpose in the teaching of biology and the founding of academies in that both laid great stress on moral and religious training. This attitude toward the subject continued until about 1850, when it was gradually replaced by a more scientific and intellectual spirit. During this early period the subject was taught in but few schools. Public and common schools excluded it entirely from their curricula. The cause of this was the mistake prevalent in so many communities of its inutility. It was looked upon as an accomplishment inapplicable to the sterner duties of life. Views of utility and immediate practical good predominated over other educational aims, and consequently natural history was excluded. Private schools paid but limited attention to it, not even so much as was paid to natural philosophy. The reason for this lay not so much in the inutility of the subject as in the lack of proper facilities, teachers, books and instruments for carrying it on. For lack of these the student became disgusted with the technicalities and theories before reaching the point where his interest and curiosity would be aroused. The method of presentation of the subject was to have the pupil memorize a certain number of pages of some textbook. Specimens, if studied at all, were used to verify statements in the book, and were less used in zoölogy than in botany, because of the nature of the subject matter. Animals lent themselves more readily to the natural history point of view, and consequently less attention was paid to their anatomy. There were no good textbooks to further even this rudimentary work. All that then existed were defective, primarily because of their untruthfulness, and secondarily because

they were translations and reprints of foreign books, which, without alteration, had been put into the hands of students. These taught about objects foreign to the pupils' environment and gave them no direct personal introduction to nature itself.

Of the defects of the method just described many of that time were well aware, and in 1837 John Lewis Russel delivered before the American Institute of Instruction at Worcester, Mass., a lecture on the "Study of Natural History." This is the first address in this country upon the subject of natural history which appears to be extant at the present day. Other addresses of earlier date, notably in the American Annals of Education for 1831, contain references to biology as a subject which has held a minor place in a few school curricula for several years. These references, however, seem to make special mention of botany, from which we may infer that zoölogy was but little studied at that date. Even at this early date we find men who deprecated the then present methods and advocated others which, in the light of modern science, have proved to be far better, for we find the claim was made in certain quarters that the only way to study natural history is to turn to nature and receive knowledge first hand. The pupil must be interested by the facts and not by abstract problems. Such interest was considered by some people adequate to prevent vice by furnishing innocent amusement and relaxation by "illumining the path of duty with the light of science." Natural history could be made a powerful instrument in the hands of Christian teachers for bringing the young "through nature to nature's God."

The history of zoölogy in secondary teaching may be divided into four periods, with their approximate dates as follows: (1) 1825-1870, a period characterized by the natural history phase of the subject, taught according to the textbook method; (2) 1870-1886, in which comparative anatomy was made the basis for work and the textbook was supplemented by verification by specimens; (3) 1886-1900, during which time comparative anatomy continued as a basis for work, but real laboratory work was introduced and the scientific world was flooded with laboratory manuals; (4) from 1900 on there has been a gradual tendency to combine the natural history phase with the comparative anatomy of the two pre-

ceding periods. This work is conducted by the laboratory method and field work. The time divisions must not, however, be regarded as strict, but as delineating in an approximate way the stages of change in teaching.

The surest indications of the tendencies of a given period are the textbooks. These, however, follow instead of lead the onward movement of method. They are written to supply a demand, rather than as an inspiration and guide to progress. The earliest textbooks were translations of foreign works, and amongst the earliest of these was Ruschenberger's series. These books were prepared from the text of Milne Edwards and Achille Comte, professors of natural history in the colleges of Henry IV. and Charlemagne, by W. S. W. Ruschenberger, M. D., a surgeon in the United States army and a member of the Academy of Natural Sciences of Philadelphia. The books were written from the physician's standpoint, and base the study of the whole animal kingdom on the anatomy and physiology of man. They deal principally with the natural history of a vast number of animals, beginning with the highest forms. Classification is the basis of all study, and is taught arbitrarily in the beginning of the work before the student has any conception of its meaning. Anatomy is treated only in connection with the higher animals, and there is confined almost entirely to external features. Birds are dealt with in regard to internal structure. That these books, six in all, supplied a keenly felt demand is shown by the fact that five editions of the first one were published during the first year, that it was introduced into the schools of Philadelphia and into nearly all first-class seminaries, and that this was followed by five more books during the four succeeding years. The method by which these books were to be used is clearly set forth in the preface. The double purpose of the study of natural history is "to impart certainty to the mind and religion to the heart." This is to be acquired by thorough mastery of the facts of natural history as set forth in books, related by teachers and gathered from visits to museums and collections. "Only thus can one become a true naturalist." The tendency toward a broader view of the study, as outlined by Mr. Russel in his address previously referred to, is recognized by the

author. Ruschenberger states in his book on Mammalogy, published in 1842, that "It is contended that natural history is best studied without the use of any books whatever, except the book of nature and its visible illustrations. This notion is entertained by persons of so much learning and influence that it is worth our while to inquire briefly whether the plan has pretensions that should lead to its general adoption." This method apparently does not meet with his own advocacy, for he urges rather the use of textbooks, lectures and oral instruction supplemented by verification in museums.

Other textbooks of this period illustrate the same general tendencies. All are written strictly from the natural history side and emphasize the religious purpose of natural history study. The value of the subject as a means of disciplining the mental powers is claimed about 1860 by Mr. Hooker, who says that for this purpose science is as valuable as mathematics or language. It cultivates the perceptive and reasoning powers together, thus forming the habit of intelligent observation. This would indicate a deviation from the stereotyped method of recitation by supplementing the memory work with observation of natural objects, and is probably the first recognition of the value of Pestalozzi's theory of object lessons in zoölogy work. Certain other changes are also to be noted which are shared by all textbooks of the time, i. e.: (1) condensation of material into one book which placed the possibility of purchase within the pupils' means and increased the convenience of both teachers and pupils, (2) introduction of the geographical distribution of animals, (3) increasing emphasis on the economical value of the study, (4) copiousness of illustrations. As representative books of these years, up to 1870, may be mentioned Chamber's "Elements of Zoölogy," Hooker's "Natural History" and Tenney's "Natural History," published respectively in 1847, 1860 and 1866. The arrangement of all of these is strictly systematic, beginning in each case with man and going down the scale of animal life to the protozoa. The introductory chapter in each book takes up the principles of classification and divides the larger groups as low as families. Cuvier's plan is followed. Vertebrates occupy considerably more than half the book in each

case. The first two, Chamber's and Hooker's, offer aid to the teacher by a set of questions at the foot of each page, which show how closely the pupil was expected to confine himself to the text. Current periodicals during the years 1860-1870 indicate at least an appreciation and hope of better work in natural science in the future. In the *New York Teacher* for January, 1864, we read: "The current is setting strongly in favor of more general study of natural science in our schools. A few years ago hardly any attention was given to it even in high schools. Now too often it is crowded into the last year of the course." Such a position argued well for future progress.

The second period in the development of natural history covered about sixteen years. A decided step forward is to be noted in the broader and more appreciative conception of the value of the subject in the uses which it might subserve, and in the change in the method of presenting the subject to accomplish these newly acknowledged aims. During the preceding decade long continued criticism of the old teaching system had begun strongly to affect the public mind, and now natural science was gladly admitted to the schools, and, as was remarked by Prof. N. S. Shaler, of Harvard, was "even unreasonably welcomed as a deliverer from all the great difficulties of education." It was, however, not yet recognized as one of the essential factors of education, because it was not widely enough known, and because of the prevailing impression that it did not offer so broad a scope for mind discipline as the classics, mathematics or philosophy, which had centuries of use to support their claims. Time is necessary to accustom the public to new educational as well as other new ideas, and natural history was only slowly winning its way to favor. It endeavored to cultivate and encourage the power of observation, habits of precision and elegance in speech and to aid in securing a good vocabulary. It aimed to give students an accurate knowledge of the phenomena of nature and of the laws governing nature. The earlier desire to bring pupils nearer to the Creator had not entirely passed away, but the earlier religious ideals had been replaced by a more practical aim.

The natural history side of animal life was plainly declining

and morphology was taking its place. Classification was still closely adhered to, but was not taught as the foundation on which all other study rested. As Mr. Morse explains in his textbook, when he places it at the end, "There is no use in studying classification until the pupils know something to classify." There was also a reversal in the order in which the various groups were taken up. Darwin's theory of evolution and a better knowledge of the lower forms of animal life had led to more attention to lower forms and had undoubtedly been influential in causing this reversal in the order of treatment. The most potent influence in shaping the work of this period was Louis Agassiz. From the little island of Penikese his influence had spread to the colleges and universities and from there to the secondary schools. Accurate observation and classification to discover "natural affinities" came to be more and more the aim and "comparison" the method of study in zoölogy. For two reasons Darwin's careful analysis and explanations had less influence in secondary work than Agassiz' "love for nature." (1) They were less adapted; (2) Agassiz was in America, Darwin was in England. There was no direct effort to teach evolution as far as I have been able to observe, but there was greater attention given to comparative morphology. The lower forms were treated almost entirely from the morphological standpoint while the vertebrates were still confined to natural history. Morphology tended to increase in importance in both classes during the sixteen years of which we are speaking.

The first textbook of the period was Morse's "First Book of Zoölogy," published in 1875, which was a decided departure from any previously written, or, indeed, from anything which followed for many years. The author has made a selection from the animal kingdom, and begins his work with the study of mollusks "because they are most conveniently studied." This is followed by arthropods, worms and a comparative and very brief study of vertebrates. The illustrations are very different from earlier ones, in that they are done in outline, following the example of Huxley's "Crayfish." A peculiar innovation is suggested by the author in connection with these drawings; that is, that they shall be copied by the pupils in order to fix them in their minds. Other text books

of the period are Orton's "Comparative Zoölogy," published in 1876, Holder's "Elements of Zoölogy," 1884, "Text Book of Zoölogy," by Nicholson, 1885, and Packard's "First Lessons in Zoölogy," 1886. The characteristics of these books are so fully exemplified by the general characteristics of the period that it would be mere repetition to enumerate them. In addition, however, should be mentioned the increasing attention to internal anatomy which marks the treatment of the lower forms of life.

Although the text books were different in several respects from those of the earlier period the method in which they were used did not differ essentially from the earlier usage. The only important change was in the application of the theory of object lessons for the purpose of verification and to aid the memory in retaining such a mass of facts. A broader conception of the usefulness and value of zoölogy in mind training gave to its methods deeper significance and importance. It was held that in order to acquire an accurate conception of the phenomena of nature two faculties must be cultivated, i. e., memory and observation. The text carefully studied trained the one while natural objects and specimens called forth the other. The latter served to verify the statements of the former. In addition to studying the text the pupil was expected, in theory, if not in practice, to dissect and make careful drawings of his dissections. Huxley is quoted by Morse as saying that a specimen should be studied with lens and scalpel in hand. Another demand on the pupil was that he should gain a knowledge of the laws governing nature. The facts gained by the use of memory and observation were to be digested and sorted by the reflective powers and arranged in their proper relations to one another. The appreciation of the training of the reflective powers by zoölogy partially accounts for the special emphasis laid on comparative anatomy. It was not the animal as an individual which was studied, but as one of a class related in structure to other animals. With this idea in mind Packard began his book with a study of the fish in order that the students might have a standard for comparison in studying other animals. This is the most extreme and advanced idea observable during this period of comparative anatomy. The con-

tact of the pupil with nature in excursions and examination of natural objects and specimens was through the medium of the text book. Independent investigation and discovery were unknown and unadvocated in secondary work. He observed only that which he had learned from the text book he was to see and when he found it used it only as a means of verification. The inconvenience of depending upon excursions for this work was gradually outweighed by the convenience of studying specimens in the school. For the successful study of comparative anatomy dissection with suitable instruments and equipment was found to be a necessity, and out of these necessities and conveniences grew the laboratory method of the succeeding period.

(To be concluded in November.)

THE SINGING AND THE SPEAKING ARC LIGHTS.

BY K. E. GUTHE.

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The interesting and striking experiments which may be performed with the singing and the speaking arcs are very little known, but require only a small number of apparatus such as can probably be found in many of the better high schools. I hope a description of some of them will prove to be of interest to the readers of SCHOOL SCIENCE.

The "singing" and the "speaking" arcs are two entirely different things. In the former, often also called the "musical" arc, noises produced by the light itself are modified in such a way as to become musical sounds; while in the "speaking," or better, "speech reproducing" arc, the arc light is made use of as a loud speaking telephone receiver.

I. THE MUSICAL OR SINGING ARC.[1]

An open arc produces hissing noises when it is too short. These sounds are probably due to the entrance of air into the crater of the arc, thus suddenly changing the electrical resistance and the current. This is followed by a variation in the volume

[1]The singing arc was first described by W. Duddell, London Electrician, Vol. 46, pp. 269 and 310, 1901.

of the incandescent vapor and thus vibrations are set up in the surrounding air which we hear as the hissing noises. In order to transform these into musical sounds we must force them to become regular vibrations.

Just as we set a tuning fork into vibrations by the irregular impulses it receives in being bowed, we may use the hissing noises of the arc as a means of starting the vibrations of an electrical resonator. Such an electrical resonator is formed by a circuit, containing capacity and self-inductance and it has a definite period of vibration, which may be written approximately, i. e., if we can neglect the electrical resistance of the wires, as

$$(1) \qquad n = \frac{1}{2\pi\sqrt{LC}},$$

where L is the coefficient of self-inductance of the circuit and C the capacity.

To form an idea of the frequency of these electrical vibrations, that is, the number of times per second the current flows into the capacity and back, we will consider the case of a condenser, having a capacity of 3 microfarads, put in series with a solenoid of double cotton covered wire, No. 21, B. & S. gauge, wound in a single layer on a cylinder, 4 cms in diameter (cross-section a=12.57 cm^2) and 40 cms long, *lsp.* There will be 416 turns of wire, N, in this solenoid.

In order to calculate the frequency n, we must reduce C and L to c. g. s. units. One microfarad equals 10^{-15} c. g. s. unit. The coefficient of self-inductance of a solenoid as described is about

$$(2) \qquad L = 4\pi a \frac{N^2}{l},$$

in our case equal to 680000 c. g. s. units. Completing the calculation for n, we obtain

$$n = 3520 \text{ vibrations per second.}$$

Putting now such a circuit consisting of a condenser and self-inductance, in parallel with an arc light, we will under favorable conditions be able to produce electrical vibrations in this system, which in its turn will react upon the arc light itself and now force the irregular disturbances to take place at the same rate,

i. e., in unison with the resonator. Probably the variations in the light consist of a rapidly alternating extinguishing and relighting. The final result is a sound corresponding to the frequency of the electrical vibrations.

In order to obtain sounds of a pitch not disagreeably high the capacity should be rather large. I obtained excellent results with a condenser having a capacity of three microfarads. The commercial condensers made by the Stanley Manufacturing Company in New York have this capacity. They are well suited for this work and cost only five dollars. With homemade condensers, consisting of tinfoil sheets, separated by paraffined paper, satisfactory results may be obtained.

If the self-inductance is too large the arc will refuse to

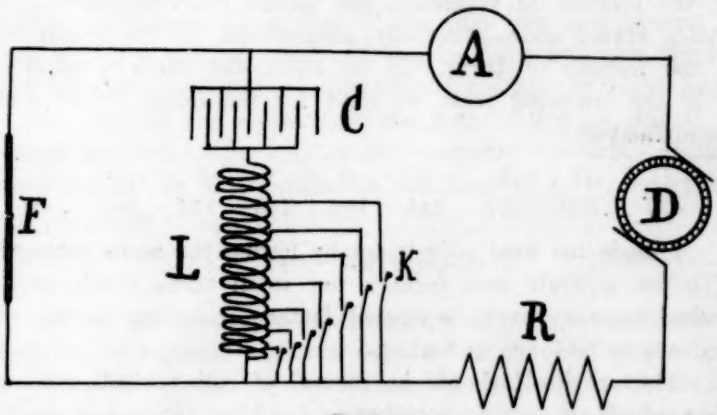

Fig. 1.

work. In the case it seems necessary to lower the pitch it is better to increase the capacity instead of the self-inductance. By varying the amount of self-inductance in the circuit tones of different pitch may be obtained and by proper selection we may construct an arc-piano on which regular tunes can be played. This can easily by done by using a uniformly wound solenoid as the self-inductance and short-circuiting parts of it by means of keys, as indicated in Fig. 1.

A short mathematical discussion will make this clearer.

Combining the above formulæ (1) and (2) we obtain

$$(3) \qquad n = \frac{1}{2\pi\sqrt{4\pi a C \frac{N^2}{l}}},$$

or by introducing $N' = \frac{N}{l}$, i. e., the number of turns per centimeter, which is a constant for a uniformly wound solenoid,

$$(4) \qquad n = \frac{1}{4\pi\sqrt{\pi a C N'\sqrt{N}}}$$

Now putting the constant factor of the expression on the right hand side equal to c, our formula reduces to

$$(5) \qquad n = \frac{c}{\sqrt{N}},$$

or, the number of vibrations per second is—with the approximation stated above—inversely proportional to the square root of the number of turns. If we select 434 turns to represent C of the tempered scale we need for the tones of the octave approximately:

C	D	E	F	G	A	B	c	
434	343	278	244	193	156	124	109	turns.

I made the final adjustment by letting the wires connecting with the separate keys form a few small turns which may be pushed together or be separated farther according as you wish the tone to be lower or higher.

The arc itself should be formed of rather small solid carbons, which are brought together by hand regulation and are then separated to a distance of only a fraction of a millimeter. For tones of higher pitch it responds more readily than to lower tones. It will be noticed that better results are obtained after the carbons have been allowed to obtain the proper shape corresponding to the very short arc.

The current for this experiment should be quite small, about 0.5 to 1.0 ampere. With our 220 volt direct-current dynamo excellent results were obtained. In general, it is better to use rather high voltage, though lower voltage—for example, our 72-volt storage battery—will suffice to show the phenomena to a large

audience. When the arc is too long, or becomes steady, the phenomenon ceases entirely.

Some striking experiments may be shown in connection with the singing arc. As explained above, the condenser is charged and discharged at a rapid rate. This current can easily be shown by inserting a low voltage lamp (4-8 volts) in the condenser circuit. It will be seen to glow brightly as soon as the arc begins to whistle, yes, even when the tones attain such a high frequency that they cannot be heard any more.

If the self-inductance is formed by a few coils of heavy copper wire surrounding a bundle of iron wire, there will be a constant reversal of magnetisation in this iron core. All the famous Elihu Thomson experiments on electromagnetic induction may be shown. For instance: Coil a rather heavy copper wire in several turns, having a diameter about that of the iron core and connect the ends by a low voltage lamp. If you hold the coil near the iron core so that the lines of magnetic force are at right angles to the plane of the copper coil, the lamp will glow, due to the current induced in the coil by the magnetic reversals. Holding the plane of the coil parallel to the lines of force, no current will be induced.

II. THE SPEAKING ARC.[1]

If we vary the current through the arc by superimposing upon it the variable currents due to the changes in resistance of a microphone when we speak into it, the arc will vibrate and reproduce the sounds falling upon the microphone. We have then a "sound reproducing," or as it is usually called, a "speaking" arc. A great number of different arrangements for the speaking arc have been proposed by various observers. I found that I could obtain very satisfactory results with the simplest possible arrangement, as shown in Fig. 2.

D is a direct current dynamo. (I suppose a storage battery able to supply the necessary current will do just as well.) *R* is a rheostat for adjusting the current, *F* the arc light. *Ch. C.*

[1]The discoverer of the speaking arc is Dr. Simon, who published the first account of it in Ann. Phys. Chem. vol. 64, p. 233, 1898; see also Phys. Ztschr. vol. 2 p. 253, 1901.

is a choking coil, i. e., a rather high self-inductance, for which I used one of the coils of a large electromagnet. Parallel to the choking coil is the circuit leading to the transmitter *T*, set up in some other room or building. Then a current due to the difference of potential at the terminals of the choking coil flows through the transmitter. A Berliner transmitter is well suited for the purpose. The difference of potential at the terminals of the choking coil should be from 6 to 8 volts.

Speaking into the transmitter will change its resistance and thus the current through its circuit. These variations are very

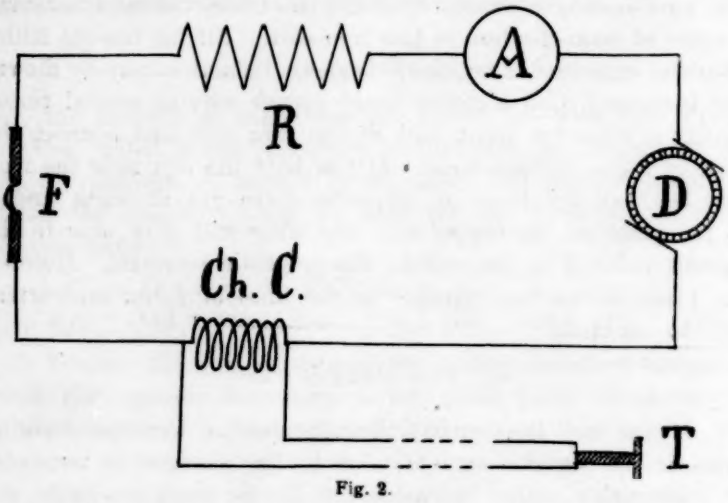

Fig. 2.

rapid, and the choking coil which offers a high resistance to rapidly varying currents will force them to pass through the arc light and the dynamo instead of short-circuiting them.

The volume of the incandescent vapor in the arc is changed and gives rise to sound vibrations in the same manner as explained in the description of the singing arc. Whatever is spoken, sung or whistled into the transmitter is reproduced with remarkable fidelity. We had no difficulty in transmitting even violin playing so that everybody in a lecture room seating over 150 people could hear every tone distinctly.

For the speaking arc a rather large current, about 15 am-

peres, is required. The arc should be very long, at least 3 centimeters. To produce a steady long arc I used large solid carbons, 1.5 cms in diameter, previously impregnated with molten sodium nitrate. This seems to have a steadying effect upon the arc. Air drafts should be avoided as much as possible, since the long arc is easily blown out.

In connection with the speaking arc, which in spite of its interesting and surprising effects must be classed with the scientific toys, it may be mentioned that attempts have been made to use it for the construction of a wireless telephone system. The light proceeding from the arc varies in intensity as the current through it varies. Let us put the arc at the focus of a concave mirror and throw the beam of light by this mirror upon another, some distance away, and there focus it upon a selenium cell. The resistance of a selenium cell is quite sensitive to changes in the intensity of light falling upon it, and it will vary at the same rate. Including this selenium cell in a circuit containing a battery and a telephone receiver, we will be able to hear in the latter the sounds which originally changed the resistance of the transmitter at the sending station. Mr. Ruhmer, of Berlin, has lately successfully established wireless telephone stations several miles apart; but, even without the rather doubtful possibility of a practical application the phenomena described belong to the most interesting discoveries recently made in the domain of physics.

A SIMPLE METHOD FOR PURIFYING MERCURY.

BY W. H. HAWKES.

Instructor of Physics, Ann Arbor (Mich.) High School.

The purification of mercury by distillation under reduced pressure or by any direct chemical process is attended by inherent difficulties that make the process unsuitable for general laboratory use. The following method will be found much simpler and less expensive: The apparatus consists of a cylindrical glass jar, say 1¼ inches in diameter and 8 inches deep, to which is

fitted a double perforated stopper, preferably of rubber, through which pass two glass tubes, one reaching nearly to the bottom of the cylinder, the upper end extending about one inch above the stopper. The other tube is bent at right angles, the lower end reaching about ½ inch below the stopper, while the upper end is connected by means of a rubber tube to a Chapman aspirator. An electric light carbon free from copper on its surface and of such a length as to reach from the bottom of the jar nearly to the stopper completes the outfit.

Fill the jar about half full of the mercury to be cleaned, pour on the mercury to the depth of about an inch dilute sulphuric acid (parts about one to ten). Introduce the carbon and insert the stopper, shake, gently rocking the mercury back and forth through the acid; this accelerates the action to take place by bringing the acid in contact with the entire mass of mercury. Now connect the aspirator, using a rubber tube, with the water faucet, and turn on the water until air bubbles up freely through the mercury. Electrolytic action between the impurities of the mercury and the carbon at once sets up in the presence of the acid, the salts produced going into solution. Allow the action to continue for about a half hour, then pour off the acid solution and add fresh acid; continue the action for a half hour longer; mercury badly contaminated may require a longer treatment.

The mercury may now be washed and dried in the following manner: Pour off as much of the acid as can be safely done and not spill the mercury. Introduce clean water, repeatedly, until the last washing gives no reaction for acid. A large, well stoppered bottle may be used for this, so that water and mercury may be shaken together. When sufficiently washed pour off as much water as possible and not spill the mercury. A pipette or siphon may be of use in removing water from the surface. Strips of clean batting paper, or folded filter paper thrust down into the mercury will further dry it. Now filter through filter paper, perforated at the point of the fold; fine perforations are needed so that the mercury passes through slowly, and the process is complete.

Impurities of an oily nature may be removed by washing in potassium hydrate and then in clean water, drying and filtering as above described.

It has been found that mercury contaminated with sulphur from rubber tubing and with zinc lead and copper from ordinary use in a laboratory can be cleaned quite effectively and with little or no loss of mercury by the process as given. Any form of aspirator may be used, as long as a considerable quantity of air is driven through the mercury.

The office of the air is a double one. It appears to remove some of the impurities by oxidation, as may be shown by going through the operation leaving out the acid. It also brings the acid by constant agitation in contact with all parts of the mercury.

POLARIZATION OF A GALVANIC CELL.

BY ARTHUR W. GRAY.

The directions given in most elementary text books on physics convey the impression that it is the simplest thing in the world to show satisfactorily the counter electro-motive force of polarization in a simple galvanic cell. And so it is if conditions are just right; but most of the directions give no hint as to the right conditions. Again, the experiment usually employed to illustrate this phenomenon shows merely that the current rapidly weakens after the circuit is made, whereas it is very easy to show in addition that this weakening is due to the presence of the gas bubbles on the copper plate, and also that these bubbles cause a counter electro-motive force, as well as an increase in resistance. When these points are clearly brought home to the pupil's mind by convincing experimental evidence, he has very little difficulty in understanding the essential action of depolarizers.

In arranging an experiment for this purpose attention should be given to the selection of a suitable galvanometer, and to the controlling of the rapidity of polarization, so that it will

take place slowly enough to be followed without difficulty. A very effective galvanometer can be constructed by wrapping ten or fifteen meters of number thirty copper magnet wire around an ordinary pocket compass having a needle about three centimeters long. A convenient mounting for this can be made by gluing back to back two pasteboard trays, each about four centimeters square and one centimeter deep. The compass should be placed in one of the trays, and the winding guided by slits cut in the sides of the other. By having a large resistance in the circuit, the action can be controlled so as to take place slowly. This resistance is most conveniently obtained by using for the galvanic cell a tumbler filled with clean water, to which has been added one or two drops of concentrated sulphuric acid. Troublesome vibrations of the needle will be avoided if the circuit is completed by immersing the copper plate, corner first, and lowering it gradually as the needle deflects. Before immersion this plate should be dry, and freshly cleaned by scouring with emery cloth.

In a minute or so an original deflection of about 45° will be reduced to 20° or less. If the gas bubbles be now brushed off the copper plate by vigorously agitating the liquid in front of it with a rubber-tipped stirring-rod, the deflection can be increased to 35 ° or more, quickly returning to about 20° when the stirring is stopped. Gently flowing a strong solution of copper sulphate over the gas-coated copper plate will destroy the bubbles and restore the deflection to about 45°. A solution of chromic acid will increase it to about 70°. Before each trial it is advisable to clean and brighten the copper plate by thoroughly scouring with emery, and to fill the cell with a fresh solution of sulphuric acid.

The strengthening of the current upon the removal of the gas bubbles shows merely that the weakening is due to their presence. If the pupils have been properly prepared they will see that the bubbles might weaken the current by introducing resistance, by causing an opposing electro-motive force, or by a combination of both. To show the presence of the counter electromotive force two copper plates are needed. After it is seen that under ordinary conditions no current passes when the cell is

set up with two like plates, it should be set up as before with a zinc plate and a copper plate, and the current should be allowed to run until the latter has become well coated with bubbles. If the zinc plate be then removed and replaced by a clean copper one as soon as the galvanometer needle comes to rest at zero, a considerable deflection in the opposite direction will be obtained, which will gradually fall back to zero again as the bubbles disappear.

This experiment has uniformly given very good results even in the hands of mediocre pupils.

If it be desired to show that the gas bubbles are hydrogen they can be collected by having the copper plate bent into suitable shape and held under an inverted test-tube of dilute acid. Of course, the cell solution for this purpose should be strong enough to generate the gas rapidly, so that an unreasonable length of time will not be consumed in collecting sufficient for a test.

I might add that a convenient shape for plates to use in a simple tumbler cell can be made by bending over to form a J-shaped hook one or two centimeters of a strip of metal about three by ten centimeters. A close coil about one centimeter in diameter formed of four or five turns of number fourteen hard-drawn brass wire soldered to the bent-over portion of the plate answers all the purposes of a binding-post. When plates of this design are hung from the edge of the tumbler, they are held firmly against the sides of the latter, so that there is no danger of their touching each other.

LABORATORY MATERIAL FOR GENERAL BIOLOGY.

BY A. J. GROUT,
Instructor in Biology, Boys' High School, Brooklyn, N. Y.

I have used Parker's Biology as a textbook in general biology for several years, and in striving to provide several hundred boys with laboratory material to accompany that admirable textbook I have devised or plagiarized several schemes that may not be known to all teachers of biology and which will certainly be useful to the younger and more inexperienced teachers. For the last two or three years I have had amœba so abundantly that each one of three hundred boys could have a specimen all to himself.

For amœba, vorticella and paramœcium I proceed as follows: I take a large valise full of quart fruit jars and a pair of rubber boots and go to a sluggish stream or pond where water plants are abundant and the mud rich and dark. I scrape the surface mud from the bottom of the stream, or better, from stones that can be lifted out of the water; I pull up the weeds and strip them through my fingers, letting the attached material drip into my jars. In this manner I fill six or more jars, which I take to my laboratory and empty into convenient receptacles. I pick out any surplus of vegetable matter, always leaving sufficient to keep the mixture good and rich by its decay. I then add water, and from time to time supply enough water to prevent drying up. In about two weeks I begin to search for amœbæ, which I usually find in abundance in some dishes, while not a solitary one can be found in others. Unless one knows how and where to look for them, he may have a million amœbæ and yet have difficulty in getting one. If your culture is just right the amœbæ, which were so scarce as to be practically indiscernible at first, will multiply to such an extent in two or three weeks that you can take up dozens with one sip of the pipette, if you choose the right spot. The surface of the sediment at the bottom of the dish is always a good

hunting ground, but my best results have come from scraping off a little of the ooze which collects on the edge of the dish just below the water line. Here minute algæ thrive and here amœbæ swarm to devour them. By tipping the dish slightly a little of this ooze can be scraped off on the point of a knife and readily transferred to slides.

There are many other methods of obtaining amœbæ. One of my fellow teachers, for instance, has obtained them in abundance from the underside of a decaying "lily-pad." But the safest and surest way is to make a culture in the manner outlined. I have found the Bronx river the best hunting ground for amœbæ and many other infusoria.

Sooner or later *paramoecium caudatum* will appear in quantities in some of my mud cultures, but after a week or two they diminish rapidly in numbers and soon will entirely disappear unless a bit of lean meat (beef) be placed in the culture, when they will develop in such numbers as to make the water whitish around the decaying flesh. (See later account.)

In making cultures for amœba and paramœcium I always leave some bits of grass or other vegetable matter, and after a week or two I am always sure to find vorticella attached to some of this vegetable debris. They can also be found attached to the sides of the containing vessel, but they can be much more satisfactorily studied if mounted together with their attachment. The related colonial forms are often met with, but are much less satisfactory for class work, because they disintegrate under the cover glass in a very short time.

Hæmatococcus, or more accurately *sphaerella pluvialis,* is easily obtained in quantities sufficient for any number of students by obtaining rock fragments from the pools in which they naturally occur. My material has always come from some pools in ledges near Burlington, Vt. I understand that several of the firms that supply botanical material for laboratory classes will supply this material. When the pools dry up, the resting stages of sphærella form a reddish-brown crust on the bottom of the pools and on any objects in them. If pieces of stone covered with this crust be placed in a glass dish of water in a moderately warm and light

place (not bright sunlight) in a day or two the water will swarm with the motile stages and will form a red line at the surface on the side nearest the light. They can easily be transferred to a slide with a pipette. They are so minute that I find it very advantageous to mount with a few fibers of cotton, which serve as a guide to focusing, prevent the slide from drying out too suddenly, and in some degree hinder the too active movements of the sphærella. If a small quantity only of material be desired it is better to scrape a little of the crust into a small beaker of water. By so doing the same piece of rock may answer for several years.

The method for obtaining fresh-water hydra recommended by the textbooks, i. e., placing some water weeds in a saucer and removing the hydra individually with a pipette, is ridiculous. I collect several quart jars almost solid full of duckweed from the surface of some convenient ditch or pool. The free, unentangled plants are much the best. Enough water to thoroughly cover is placed in each jar. The jars are carried, as soon as possible, to the laboratory and emptied into glass jars holding from two quarts to two gallons and the jars filled up with water. The next day the hydra will be found clinging in great numbers to the sides of the dish, if the catch is a good one. I then remove most of the duckweed and partially change the water. Great care has to be taken to remove all the organic matter except a few plants of duckweed, for any appreciable decay will kill the hydra very rapidly. On the second day I usually entirely change the water by pouring it off, as the hydra will cling to the sides of the vessel. The hydra will perish in the closed collecting jars in a few hours, and must be removed as soon as possible, if they are to remain healthy. The hydra will live for a long time without feeding if other conditions are favorable, but a whole aquarium full will sometimes suddenly vanish as if by magic. If the animals be distributed in small receptacles, like fruit jars or ordinary drinking glasses, this wholesale disaster may be avoided.

A friend often collects large quantities of *hydra fusca* by picking up sticks and stones at the bottom of a clear, moderately swift brook and then putting in fruit jars and treating precisely as outlined above for the treatment of the hydra on duckweed.

A small stone the size of one's fist will sometimes have hundreds of individuals attached to it.

Oscillaria I find readily in slow-flowing streams contaminated with sewage.

Vaucheria can be found in winter and early spring in almost any greenhouse and can be made to produce sexual organs by washing clean and putting in clear water. Organic matter in the water sufficient to cause decay will be fatal. In the greenhouses also one can usually find an abundance of fern prothallia and various stages of development of the mosses.

ELEMENTARY EXPERIMENTS IN OBSERVATIONAL ASTRONOMY

BY GEORGE W. MYERS.

(*Continued from page 173.*)

If a star has a parallax of one second, it is then 206,265 times 93,000,000 miles from the eye; if the parallax is 0″.8 the star's distance is $\frac{206{,}265 \times 93{,}000{,}000}{0''.8}$ and, in general, if the star's parallax is denoted by p'' and its distance in miles by D, we have

$$D = \frac{206{,}265 \times 93{,}000{,}000}{p''}$$

For most stars p'' is small, and D is so large a number that a longer unit than the mile is preferable. The ordinary unit is the *light-year,* which is the distance that light travels in one year at the rate of 186,000 miles (=300,000 kilometers) per second.

Find the distance in miles and light-years to the stars tabulated here from the parallaxes placed beside them:

*For the convenience of those who may desire to use these experiments (there are forty-four of them) in their classes, they may be obtained in pamphlet form from "The School Science Press," Ravenswood, Chicago, at 25 cents a copy, and $2.50 a dozen.

	Star.	Parallax.
1.	*a* Centauri	0″.75
2.	61 Cygni	.40
3.	Procyon	
4.	70 Ophiuchi	.25
5.	Vega	.16
6.	Polaris	.074

Prove that $D = \frac{3.26}{p''}$ gives the distance to any star in light-years, p'' being the parallax of the star in seconds, and D the distance from it to the earth, or sun, in light-years.

Experiment XXXVIII.

To find distance from earth to sun by geometrical methods connected with transit of Venus observations.

(a) *Observers are displaced in longitude.*

Let S, V, and E denote the sun, Venus, and the earth, respectively.

When Venus is in line with the earth and sun, and between them, she is said to be in *inferior conjunction;* when in line, but beyond the sun, she is in *superior conjunction.* Observation shows that Venus requires 584 days to pass from either conjunction to the same conjunction again. This is the same as saying that it requires Venus 584 days to gain a complete revolution, or 360° on the earth. The daily gain is accordingly ....° = 37′ (nearly); or 1′ 32″.5 per hour.

Two observers at stations A and B as far separated in longitude as possible on the earth; note the instant when Venus touches the solar disk. Of course, the easternmost observer at $A1$ sees the beginning of the transit first. Venus moves onward in her orbit to $V2$, when the western observer sees the first contact of Venus with the sun's disk. Evidently Venus, in the meanwhile, has gained the angle $A2\,D\,B2$ on the earth. If an observer were at D, this is the angle under which the chord $A2\,B2$ of the earth would be seen by him. If the observers at A and B are 6,000 miles apart in a straight line (and a former experiment has taught us how to compute this distance), and the angle is

found to be 13″.2, since any magnitude must be 15,500 times its own dimension from the observer to open up 13″.2 at his eye (Experiment IV.), the distance to the sun $D\ A$ (or $D\ B$) equals 15,500×6,000=93,000,000 miles. This exercise may be studied

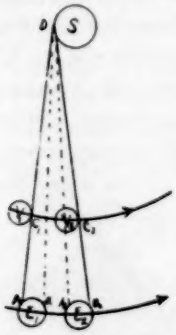

Fig. 35.

concretely by cutting out three wooden disks and attaching strings by light staples, carpet-tacks, or pins, as the lines are drawn in the cut.

Using the data of any table of planetary elements and substituting in the problem, work through and check the value of the distance from the earth to the sun.

(b) *Observers displaced in latitude.*

To obtain as long a base line as possible one observer should select a station as B in as high northern latitude as possible, and

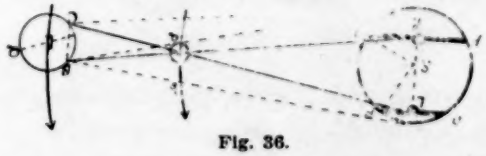

Fig. 36.

the other at C in as high southern latitude as possible. ($E\ Q$ denotes equator.)

To an observer at the northern station, B, at the time of a transit, Venus will be seen projecting on the disk of the sun, while she is crossing a cone whose vertex is at the observer, B,

and whose elements are tangent to the sun's surface. Experiment XXXV. will show that Venus is at 0.72 of the earth's distance from the sun, so that the cone where Venus crosses it is only 0.23 of the solar diameter. The line *ab*, seen from *B*, is 32′ .04″ on the average, *when the transit is central.* Seen from *S*, the line *ab* would then have the angular magnitude 0.23x 32′.04″=10′ 14″.6. (See under "a"). The hourly gain of Venus on the earth is 1′ 32″.5 on the average, and the duration of a transit of Venus, which is central, is then 6.64 hours. The duration of other transits will sustain such a ratio to 6.64 hours as the lengths of the chords of the solar disks traced by Venus' projection on the sun during transit sustain to the angular solar diameter 32′ .04″.

This latter diameter is directly measurable in terms of angular units, and the chords traversed by the projection of Venus are readily computed from it.

If then viewed from *C* in high south latitude, Venus seems to describe a path such as *FG*, and from *B* a path such as *DH*, computing the times of transit with 6.64 hours, we find the ratio to 32′ .04″ of the lengths of these arcs in angular value (*SD* and *SF* being 16′ .02″). *SK* and *SL* are readily found by the Pythagorean Proposition.

[Note: *GF* is to 2*SD* as the time of transit along *GF* is to 6.64 hours.]

Angles *BVC* and *DVF* being equal, and *BC* and *LK*, or *FD* being supposed parallel, we have the triangles *BVC* and *FVD* similar; hence:

$$\frac{FD}{BC}=\frac{VB}{VS}=\frac{28}{72}, \text{ or } FD=0.35\ BC.$$

The observers *B* and *C* know their latitudes and longitudes and compute the length of *BC*. The line *FD* then becomes known in miles. Knowing, then, the length of *FD* in both degrees and miles, we compute, then, how many degrees and miles there are in *LK* and how many miles in *SD*, and we then have how many seconds one mile or 4,000 miles correspond to when seen over the distance from earth to sun. It is found that 4,000 miles viewed from the earth-sun distance would subtend an angle

at the eye of 8″.8. But experiment V. would show us that to make any magnitude open up 8″.8 at the eye it must be placed 23,250 × its own length from the observer. Hence the distance to the sun is 23,250×4,000 miles (roughly)=93,000,000 miles.

Cut out two circular wooden disks such as *BQC* and *FGHD*, and fasten two strings with staples, one at *B* and *D* and the other at *C* and *F*. Running the strings through a bead at *V*, the problem may be made to stand out before the eye concretely. Globes will be better than disks if they are available.

THE PRECESSIONAL GLOBE.

Description: *P*. The north pole of the heavens. *Q*. The

Precessional Globe.

Fig. 37.

north ecliptic pole. *R*. Brass circle with center at pole of ecliptic, radius, 23½°. *M*. Meridian graduated to degrees. *S*. Scale graduated on one edge to miles and on other to degrees. *T*. Thumb-screw to carry and clamp *S* along meridian. *H*. Wooden horizon, graduated. *E*. Equator. *C*. Ecliptic, and *D*, sliding support to *M*.

The circle R is perforated with 26 equally spaced holes, extending entirely around it, and around the south ecliptic pole is

another precisely similar circle. At P is a pin, held in place by a spring, which may be set in any one of the twenty-six holes, a similar pin being first set in the diametrically opposite hole of the south pole circle.

Since the precessional motion carries the poles of the heavens around these circles once in 26,000 years, the spaces between adjacent holes corresponds to the motion of the poles during 1,000 years. It is therefore possible to bring the globe into such positions as to represent the aspect of the celestial motions about the instantaneous pole positions for any integral number of thousands of years of the past or future. The positions of the poles for *any* epoch may be represented on this globe, while on an ordinary globe they can be represented for only a *single* epoch. The following important astronomical facts may be visualized by proper settings of the globe:

1. The revolution of the First of Aries through the signs of the zodiac.
2. The revolution of the celestial pole about the ecliptic pole.
3. Changes in the right ascensions and declinations of the stars.
4. Changes in the longitudes of the stars, but not in their latitudes.
5. The tropical year is shorter than the siderial year.

Exercises to be solved with the precessional globe.

Experiment XXXIX.

To determine the Polestar at any given epoch.

(a) What star was nearest the north celestial pole when the great pyramid of Cheops was built 6,000 (?) years ago?

(b) What star was nearest 1400 years ago? 1400 B. C.? 8500 B. C.? 14000 B. C.?

(c) When will Vega be the Polestar?

(To be concluded in November.)

NOTES ON THE PROGRESS OF CHEMISTRY.—I.

BY LYMAN C. NEWELL, PH. D.

It is the purpose of SCHOOL SCIENCE to publish at intervals notes on the progress of the chemistry which is of special interest and service to teachers. No attempt will be made to cover the field nor to reproduce whole articles. But we trust that the matter selected will meet the wishes and needs of busy teachers.

Chili Saltpeter. By Emory R. Johnson, Jour. of Geog., February, 1902, page 55.—Part of an account of the industries of South America. The salt "lies in a nearly continuous deposit parallel to the seacoast, extending 150 miles from north to south, with scattering deposits reaching 250 miles farther, the total covering 220,356 acres, and estimated to contain about 228,000,000 long tons. The nitrate is found under the surface layer of sand, and when shoveled out has the consistency of cheese. It is refined in numerous plants requiring large capital. The crude product is dissolved, chemically treated, and crystallized to remove the impurities. Among these impurities are compounds of iodine and common salt."

The Molecular Weight of Sulphur. By Charles F. Lindsay, Amer. Chem. Jour., March, 1902, page 220.—A review of the recent work on this problem. "It has been shown that at the lowest temperatures at which sulphur can be vaporized it exists as S_8. As the temperature rises, this commences to break down into the molecules S_2, while at temperatures above 900 degrees sulphur exists solely as S_2. In solutions it exists as S_8."

Solid Carbonic Acid from "Sparklets." By R. W. Wood, Sci. Amer., March, 22, 1902, page 203.—Remove the top of the siphon bottle, insert the cooled "sparklet" capsule, tie tightly over the (inner) end of the tube a piece of black velvet so that a small bag is formed, screw down the cap, and the gas which escapes into the bag will solidify. A drop of mercury may be frozen in a few seconds by the solid carbon dioxide.

Preparation of Tantalum in the Electric Furnace. Sci. Amer., April 5, 1902, page 236.—Detailed account of the preparation and properties of pure tantalum. Potassium fluotantalate treated with sulphuric acid yields tantalic acid. The latter mixed with sugar charcoal and heated in a graphite crucible for ten minutes with a current of 800 volts and 60 amperes yields the metal in a fused state. The cooled metal has a brilliant luster and crystalline fracture. It will scratch quartz, is infusible in the oxy-hydrogen blowpipe flame, insoluble in *aqua regia*, soluble in nitro-hydrofluoric acid. Its density is 12.79. It is attacked by fluorine at

the ordinary temperature, by chlorine at 150 degrees C. and vigorously at 250 degrees C., oxygen at 600 degrees C., by gaseous hydrochloric acid, by ammonia gas, not by iodine (at 600 degrees C.), nitrogen, phosphorus, arsenic, and antimony. It reduces sulphurous acid and lead oxide.

Sulphuric Acid and Its Preparation by the Contact Method. By J. Elliot Gilpin, Amer. Chem. Jour., March, 1902, page 227; *Sulphuric Acid and Its Manufacture by the Contact Process.* By R. Kneitsch. Translated by Jas. L. Howe. Pop. Sci. Mo., May, 1902, page 24.—The first article is a technical account of this process and the second is a popular translation of a general non-technical lecture on the same subject. A brief account is also publishe din the Pop. Sci. Mo., March, 1902, page 479. We quote from this article: "Theoretically the process is a model of simplicity. The gases from the pyrites burners, consisting chiefly of sulphur dioxide, oxygen and nitrogen from the air used, are, after purification and cooling, led through cylinders containing plates on which a contact mixture, with platinum as one of its constituents, is placed. The sulphur dioxide burns with the oxygen present in the gas, giving the trioxide, which is absorbed in a dilute acid. The acid obtained may be pure sulphuric acid, or may contain an excess of the trioxide—the fuming or Nordhausen acid. Several years of most patient investigation were, however, required before the conditions were discovered by which the process could be kept in continuous operation, there being a great tendency for the platinum mixture to cease its work after a few days' or even hours' use. This was due to the presence of impurities in the gas from the burners and especially to arsenic. The slightest trace of this element at once inhibits the action of the platinum." This method furnishes a strong acid free from arsenic.

The Liquefaction of Hydrogen. By F. H. Getman, Pop. Sci. News, June, 1902, page 135.—A resumé of the various attempts to liquefy hydrogen, special stress being laid upon Dewar's work. Accurate, complete, interesting. Illustrated by three figures.

Some Recent Work on Hydrogen Dioxide. By F. H. Getman, Pop. Sci. News, May, 1902, page 111.—Review of the work of Bredig and Calvert, proving that hydrogen dioxide has weak acid properties. Five methods were used. (1) When a substance divides itself between two solvents, the ratio of the concentration in each remains constant, provided the solute has the same molecular aggregation in each. Water and amyl alcohol gave the partition coefficient 7.03. Addition of sodium hydroxide changed this constant, showing the formation of a compound—a salt consisting of one molecule of sodium hydroxide and one and a half molecules of hydrogen dioxide. (2) The freezing point of $\frac{N}{4}$ sodium hydroxide solution was not lowered by adding $\frac{N}{6}$ hydrogen dioxide—a

salt having been formed. (3) The retardation of the saponification of ethyl acetate by sodium hydroxide was found to be proportional to the amount of hydrogen dioxide present—thus proving the removal of sodium hydroxide from the field of action by the hydrogen dioxide. (4) The conductivity of sodium hydroxide is diminished by the addition of hydrogen dioxide—the latter acting like a weak acid. (5) Hydrogen dioxide moves as an anion (this proof needs the figures and data of the article).

A Dry Salt Sea in the Desert. By Arthur Inkersley, World's Work, May, 1902, page 2105.—Illustrated description of the field of crystallized salt at Salton, California, in the Colorado desert, a little north of the Mexican border line. The deposit is 264 feet below sea level, and covers a thousand acres. The salt is supplied by springs from adjacent hills. The crust left by evaporation is almost pure salt from ten to twenty inches thick. A massive plough throws up the salt into furrows. It is then hoed in salt water to remove earthy matter, stacked in conical mounds to drain, and later removed to the mill. Here it is ground, sifted, and packed in sacks for shipment. The quality is good, but much is sold unrefined as "hide salt." The laborers are Indians and Japanese, because no white man could endure the heat (140 degrees F.), the reflection of the sun and the painful thirst. The supply of salt seems inexhaustible.

Ammonium. Science, March 14, 1902, page 434.—An exhaustive series of experiments by Moissan failed to give any evidence of the existence of the radical, ammonium. His work included the electrolysis of ammonium chloride and ammonium iodide in solution in liquid ammonia, the examination of ammonium amalgam when in a perfectly stable condition, and the action of liquid hydrogen sulphide on lithium-ammonium and calcium-ammonium at —75 degrees. He believes that under some circumstances ammonium hydride, N H, H, exists.

See, also, On the Existence of Ammonium. Amer. Chem. Jour., Jan., 1902, page 77, and Metal-Ammoniums. Ibid., June, 1902, page 489. The latter is an accurate review of Moissan's work above mentioned.

Radio-Activity. By Robert K. Duncan, Harper's, August, 1902, page 357.—Popular article on the discovery of this new property of matter. Includes an account of the discovery of radium. Illustrated by thirteen figures and also by portraits of Becquerel and the Curies. "Radium has never been isolated. We know that it exists as an element solely and completely through the fact that every element has its own sign manual or spectrum. The lines [in the spectrum of radium] are caused by no other known element on the earth or in the heavens. Therefore radium is a new element." The spectrum was obtained from a minute quantity of pure radium chloride.

Metrology.

HOW UNCLE SAM GOT A DECIMAL COINAGE.

BY DR. WILLIAM H. SEAMAN.

About a year ago a small party interested in the metric system of weights and measures discussed the apparent anomaly of the United States adopting a decimal currency while adhering to the old English weights and measures. None of the party could give the history of the matter, and inquiry developed the fact that but few knew of any direct source of information, so the writer concluded that a summary of the result of inquiries on the subject would interest other people. The use of silver and gold as money antedates written history. These metals have always been the preferred money of the people most advanced in civilization, but very many other substances have been used for various reasons. In Tartary people used cubes of pressed tea, in Rome and Germany cattle, in the West Indies sugar, in Mexico soap, in Campeachy logwood, in Abyssinia salt, in Africa cowrie shells (also in Asia) and in America wampum. Rome had money of leather and of wood, Virginia used tobacco and slaves, Newfoundland cod fish, Syracuse an ancient Britain tin, Sparta iron, Burmah lead, Russia platinum, China silk, Scotland nails; all modern nations have made believe paper was money, and furs and skins were in common use in the early history of this country. In 1636 the Colonial Assembly of Massachusetts allowed the towns to pay their taxes in corn, and about the same time also declared that "Musket balls of a full boare should pass currently for a farthing apiece, provided that noe man be compelled to take above 12 pence at a tyme of them." The first use of metal as money appears to have arisen from the payment of taxes or contributions to those in authority in pieces of metal which were then stamped with their weight and fineness and paid out again as is now done

*Communications for the Department of Metrology should be sent to Rufus P Williams, Cambridge, Mass.

in an assay office. The making of pieces of uniform size, shape and quality came much later. The early money was made by setting a die in a block of wood, forming a small ball of the metal and placing it on the die, then setting a punch on the metal and striking the punch with a sledge. Later a ring was put round the die, and the face of the punch was likewise engraved. A screw press was first used by Antonie Brucher in France in 1553, but it cost more than the punch, and in both France and England was given up for awhile.

All the world was at first on a silver basis. Abraham bought a tomb for Sarah with "four hundred shekels of silver" 1,859 years before Christ. A hundred and thirty years afterward Joseph was sold for twenty pieces of silver. The phrase "pieces of silver" probably refers back to the time when the pieces were not all the same size—in a word, when the metal was a commodity, and a convenient measure of value, but not a coin. The earliest existing coin is the Lydian states—an alloy of gold and silver, made about 700 years before Christ. The making of coins was not limited to the larger governments, but, during the Grecian history, every city made its own coins, and at the same time a great deal of foreign money was in circulation in Greece. A similar condition of things prevailed during the middle ages in Europe. The great merchants, the Fuggers, struck 80,000 gold gulden in their private mint at one time to pay a fine levied on their native city by the Emperor, Charles V.

Partly by hoarding, caused by the insecurity of property, and partly by the demands of the new-found commerce with the East at the time of the discovery of America the quantity of precious metals in Europe in actual use had somewhat diminished. At this time the relative value and use of gold had increased, but the flood of silver, poured into Europe by the Spanish colonies in America, made it the most important metal for commercial purposes. It is curious to note that the entire history of the invention of money among the earliest of the human race was repeated by the Spanish conquerors of New Spain. In Peru, at the time of the Spanish conquest, copper was more valuable than gold. The coming of Europeans soon changed their relative value to

the standard of Europe. All precious metals paid one-fifth to the King of Spain, and they were then cast into bars, or the gold was sealed up in little bags with the royal seal, having their weight, fineness and value in Spanish coin marked on them, just as somewhat similar practices marked the beginnings of California and Australian gold digging. Meantime Spain was not slow to perceive that she held the control of the world's supply of the precious metals, and it became her study to endeavor to secure for her government as much of the product as possible. She forbade the exportation from Spain of coin, in order to exact a heavy tax, above one-fifth, on stamping the metals got in the colonies, and when the colonists tried to avoid this impost by weighing out the crude metal they were forbidden to do so till it had been stamped. In addition, the king made numerous arbitrary changes in the value of his coins and in the relative values of gold and silver. The king's dues must be paid in coins of full weight, the public expenses were met with clipped coins. Numerous counterfeits made their appearance, due bills made of leather circulated in 1586 in San Domingo and Porto Rico. The first mints were established in 1535, but the exactions for coining bullion into money soon became so great that in three years the colonists refused to bring bullion to the mint. They were allowed to coin only silver. It was not till 1589 that gold and copper could be minted in America. The American viceroys had used many different weights and measures, but by the decree of 1581 these were all superseded by the weights and measures of New Castile, and in 1608 the cost of coinage was lessened and the amount made practically unlimited. This act did not take full effect till England, in 1666, reduced her charges for coinage to a reasonable figure, and the ease with which silver could be surreptitiously taken over to Britain destroyed the monopoly of Spain in silver money. An enormous variety of coins was in use in Europe at this time, many of which were brought over to this country by the emigrants. The money of account in Spain was reals and maravedis, but she had a dozen different kinds of coins, of which the value varied almost from year to year, according to the whims of her rulers. Among them was a piezas d'ocho, or piece of eight, so called be-

cause it was worth eight reals. The phrase piezas d'ocho seems gradually to have been contracted to piezas alone, then to pesos or peso, and in this form it survives today. Among the private mints of the middle ages was that of Count Schlick, 1517-23, in a valley known as Joachims Thal, Bohemia, and as the plural of that is thäler, the pieces they coined became known as Joachimsthäler, and finally simply thälern. They were maintained of the same value, about one ounce of silver, and hence became an acceptable currency over central Europe, and the name has been adopted for their principal coins by Sweden, Norway, Denmark and the United States. This coin and the Spanish peso were substantially identical; in fact, the Spaniards sometimes used the word dalera in place of peso, and the mints of both Spain and Mexico turned out large quantities of these pieces. The early colonists found a most profitable commerce in sending their grain, fish and rum to the Spanish settlements in the West Indies and the Spanish main, and in bringing back Spanish milled dollars, and thus this coin became more general than any other throughout the colonies long before the Revolution.

The advocates of a change in our weights and measures are often met with an apparent belief in the fixity of such matters, as if the present conditions had always existed, and therefore should not be disturbed. A very little acquaintance with the history of the subject will dissipate any such ideas; we have changed and are changing them, and the main question is whether the changes shall be made according to a carefully selected and settled plan, or whether they shall be left to chance, as hitherto.

In the early days of the present writer Mexican shillings and sixpences were universally current in the city of New York and farther south. My father was quite able to calculate in pounds, shilling and pence, a kind of arithmetic that was far from simple, since the Irish pound was as twelve to thirteen of the English pound, and 100 New England pounds were worth 75 English pounds, while 100 New York pounds were worth £56 5s and 100 New Jersey £60, and livres, piastres, Johannes, Joes and half Joes were common as shillings, and when it comes to measures, who of the present generation will recognize this table

from an old arithmetic, especially if recited in sing-song style common for recitations then:

Four pecks	make one bushel,	7 pounds	make one clove,
Two bushels	do. one strike,	2 cloves	do. do. stone,
Two strikes	do. one coom,	2 stones	do. do. tod,
Two cooms	do. one quarter,	6½ tods	do. d . wey,
Four quarters	do. one chaldron,	2 weys	do. do. sack,
Five quarters	do. one wey,	12 sacks	do. do. load.
Two weys	make one last,		

Such were the tables in Dilworth's arithmetic in 1789.

(To be continued.)

NOTES.

Colonial Premiers Recommend Metric System.—The Colonial Congress, held in London, England, at its final session, August 11, passed a resolution favoring the adoption of metric weights and measures throughout the British Empire. Though this makes nothing mandatory, and exclusive use of these measures must depend upon legislative action in each colony, the act of the Colonial Premiers is of far reaching influence. The resolution, with others, was in the interest of trade, and it is believed that colonial parliaments will not long refuse legislative aid to increase foreign commerce and improve conditions at home. The various resolutions will soon be issued in a parliamentary paper, and a metric bill, we are informed, will be introduced in the House of Commons or House of Lords.

In the Textile Industry.—At the February meeting of the Board of Trustees it was voted to make the metric system the standard system of weights and measures for the Lowell, Mass., Textile School. The importance of this act can hardly be overestimated in the textile industry, as the school is one of the largest and probably has the most varied equipment of any similar school in the world. Its trustees and incorporators are manufacturers and practical business men, representing a capital of over $65,000,000.

Another indication is that in March the Secretary of State of India, in response to many urgent requests, wrote the British Association of Chambers of Commerce to get the consent of manufacturers to use the metric method of count. One letter states: "The Indian dealers have got so accustomed to the Continental [metric] count of worsted wool yarn that they absolutely decline to give orders for yarn made up according to the British standard of count, and stipulate, when giving orders, that the yarn must be made up according to the system in vogue on the Continent." Other letters were of similar import. The Chambers of Commerce replied that they "approve the metric system of notation for woollen and silk yarn exported to that country."

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of great value.

BOTANY.

NOTES ON THE STUDY OF SEEDS.

1. To furnish opportunity for observing those features of plant growth which cannot be seen above ground, the following simple plan has been used. A glass tumbler containing moist sawdust was given each student. In this were planted seeds which were placed against the glass with the micropyle pointing outward. Thus the early development of the embryo was followed and in a little while material was at hand for the study of roots and root-hairs. A larger and better arrangement for illustrating the same thing is described in Ganong's Teaching Botanist. In performing experiments to show the relation of moisture and temperature to germination, I have also found this device convenient, that is, to plant seeds against the side of the tumbler where the number that germinate under the varying conditions of moisture and temperature can be noted.

2. In order to see to what extent seeds are able to withstand the low temperature of our New England winters, the members of the class have collected and planted seeds that had weathered the winter and were found still clinging to the plants that bore them. An account has been kept of the number of each kind planted, and the number that germinate will also be observed.

3. While studying seed-locomotion, a beaker filled with water was given each student, who experimented to learn what seeds would float after being left in water for a little time. It was found that quite a number which had special appendages for distribution by wind or animals were undoubtedly able to take advantage also of running water. One interesting case in particular was the seed of the milkweed. The little rim around the seed was found to serve a double purpose, not only to aid in distribution by wind, but by water as well, for while the seed ordinarily floats, it sinks when the rim is removed.

GILBERT H. TRAFTON.

Book Reviews.

Outlines of Botany for the High-School Laboratory and Class Room. Based on Gray's Lessons in Botany—By R. G. LEAVITT, A. M., of the Ames Botanical Laboratory. 13½x21½ cm. The American Book Company.

Teachers who have found so many good points in Gray's Botanies and have used his text in the high school will welcome the appearance of this little book. In the small space of this notice an idea of the book is best given in the author's words, quoted from the preface:

"The descriptive text follows in the main the sequence of topics of Gray's 'Lessons in Botany,' and certain parts in that book have been retained, as occasional paragraphs will show * * * without quotation marks. * * * But the greater part of the descriptive text throughout is new, the chapters on cryptogams and on physiology being entirely so."

"The book offers (1) a series of laboratory exercises in the morphology and physiology of phanerogams; (2) directions for a practicable study of typical cryptogams, representing the chief groups from the lowest to the highest; and (3) a substantial body of information regarding the forms, activities, and relationships of plants and supplementing the laboratory studies."

Laboratory Manual in Elementary Biology—By FREDERICK DEFOREST HEALD, M. S., PH. D., Professor of Biology in Parsons College (Ia.). 14x21½ cm. Willard N. Clute & Co., Binghamton, N. Y.

"The guide is intended for an elementary class of biology, with the work extending throughout the year." That it is specifically for college work is indicated by the further statement of the author: "The directions given in this manual are the result of work that has been done with college students during the past six years."

It aims to be a mean between the extremes of the "question method." The title "biology" seems scarcely to fit a manual that gives only the morphology and anatomy of the types selected, ignoring the physiological side. The types taken up are the thallophyta, bryophyta, pteridophyta, spermatophyta, and then protozoa, coelenterata, vermes, echinodermata, mollusca, arthropoda, vertebrata. L. V.

A University Textbook of Botany. By DOUGLAS HOUGHTON CAMPBELL, PH. D. Pp. xvi—550. Illustrated. New York. The Macmillan Co. $4.00.

This textbook, planned to replace in America that of Strasburger, Noll Schenck and Schimper, is the most extensive in scope of any American textbook in botany which has yet appeared. Its plan briefly stated,

is as follows: After an introductory statement of the elementary problems of the biologic relations of animals and plants, and of the role of matter and energy in the organic body, the plant body and the plant cell receive in turn a considerable treatment. Classification is then taken up at length, the system of Engler and Prantl being chiefly adhered to. The three chapters at the close of the book deal successively with physiology, relation to environment, and geological and geographical distribution.

It is to be regretted that in a work of so much *prima facie* importance the treatment of the different parts should be so unequal. Remembering that quantity and quality are by no means constantly associated, it is at least some indication of the relative value of the treatment of the physiological aspect of botany that only 32 pages out of 550 are devoted to it. The deficiency is in part made good by more or less physiological matter appearing in various places elsewhere, but after perusing the text, we believe that at best, the general criticism remains true, that the work would be much more satisfactory with a more equal treatment.

The same criticism, applied in detail, may also be made of the part on general morphology appearing under the head of the "plant body," an apt enough term for discursive use but lacking the virtue which would warrant its substitution for the still pertinent term "general morphology." For example, the discussion of the thallus is very brief and inadequate, in point of view of the student's needs, and other matters might well have been sacrificed in order to give such topics a fuller discussion. The portion dealing with the plant cell on the other hand is very good indeed.

The bulk of the volume is given, as might well be expected, to special morphology and classification, and of the subkingdoms those of the Bryophyta and Pteridophyta are well done. The result of the author's previous training in these fields has stood him in good stead.

At the opening of the chapter dealing with the Spermatophyta we find a presentation of the subject of embryology, and, though we confidently looked for an account which would give the student a modern view of the subject, we are rather disappointed. We find but a meager reference to the phenomenon of double copulation, so-called; parthenogenesis in the seed plants is not mentioned, though certainly "well authenticated"; but little attention is given to the behavior of the antipodal cells and in this connection it can hardly be said that the "case of *Sparganium* is the most remarkable yet observed" for the condition in the grasses is at least as much so. The concluding chapters on ecology and distribution are brief and summary and are illustrated with several good full-page halftones.

The work is otherwise very fully illustrated, many of the figures being taken from the author's previous publications. Others are from

different sources, some having been redrawn, and some taken from the original plates. There results an exceptionally heterogeneous collection, which is not a necessary objection, perhaps, were it not that many are crude, unjust to the originals, and lacking in significance in such a book. The distribution of the figures is often quite unfortunate, some appearing in text quite foreign to them. This makes appear worse than unnecessary the repetition of some of the illustrations.

To each chapter is appended a bibliography which would be more serviceable if many papers of first importance of American, not to mention foreign, botanists had been cited. It would be no detriment, also, if the citations were correct, which in many cases they are not.

In spite of many criticisms of detail, Professor Campbell's book will be of great value to the college student in botany, although it is far too advanced and detailed for the secondary school. For the high-school teacher, however, it will be a very great help to have a treatise of this kind for reference, and by its means these may familiarize themselves with many groups of plants which are a great deal too little known in secondary work.

FRANCIS E. LLOYD.

Suggestions for Progressive and Correlative Nature Study. By G. W. CARVER, M. AG. Pp. 18; octavo. Tuskegee Institute Print, 1902.—

This little pamphlet is the first number of a series of nature study guides primarily prepared and intended for the students of Tuskegee Normal and Industrial Institute. The author does not offer this work as original, but acknowledges its sources, so far as subject matter is concerned, in the various standard works, to which he has added some features which are the result of his own experience. The purpose of this series is through nature study to bring about the results commonly expected from all our pedagogical labors. The method employed is the laboratory and field method common to the best scientific work in secondary schools. Observation by the pupil, questions by the teacher, collection of the proper material, statement of the necessary fact by the teacher, drawing of the object studied, the drawing of simple but logical conclusion, simple experiments and training in the proper use of language, all have their place in exercises which are grouped so as to lead the pupil from simpler to more complex exercise of his mind. The material chosen for the pupils' work is that to be readily found anywhere about their homes or the school. The experiments are but controlled phenomena commonly occurring all about the pupils in their daily surroundings. The following quotations illustrate the development of the work:

LEAVES.

Exercise No. I.

(a) Are they all alike?
(b) If not, tell me in what way they differ.
(c) Bring a specimen of each one to class tomorrow.

Exercise No. II.

(a) Hold an oak leaf to the light and tell me what you see.
(b) What are the little veins for? (Teacher explain.)
(c) See if the veins in all the leaves are alike.
(d) What plants retain their leaves all winter, and by what general name are all such plants known?
(e) Of what value to the plant are the leaves? (Teacher explain.)

Exercise No. III.

Draw as many different shaped leaves as you can find upon the paper mulberry, and bring to class.

WRITTEN WORK.

Exercise No. XXXI.

(a) Walk briskly for twenty minutes, covering as much territory as possible; tell what you saw.

(Teacher.—Too much stress cannot be placed upon the importance of this request, as the object here is to train the mind to comprehend at a glance what passes before the eye.)

Exercise No. XXXII.

Take a plot of ground, anywhere on the campus, ten feet square, study it for ten minutes, and write the result of your observations.

(Teacher.—Here minute details are desired.)

Several unfortunate little errors of English were overlooked in the preparation of this paper. The text is illustrated by one full-page half-tone from a photograph, and by nine line-cuts by the author.

Teachers interested in this line of work may obtain copies from the author at Tuskegee, Ala.

E. L. M.

Books Received.

Nature Study and Life. By Clifton F. Hodge. Ginn & Co., Boston. 1902. xvi and 514 pages. $1.50.

Animal Forms. By David S. Jordan and Harold Heath. D. Appleton & Co., New York. 1902. vii and 258 pages. $1.10 *net*.

Animal Activities. By Nathaniel S. French. Longmans, Green & Co., London and New York. 1902. xxi and 262 pages. $1.20.

Inorganic Chemistry. By A. F. Holleman; rendered into English by Hermon C. Cooper. John Wiley & Sons, New York. 1902. viii and 458 pages. $2.50.

An Introduction to Physical Geography. By Grove Karl Gilbert and Albert Perry Brigham. D. Appleton & Co., New York. 1902. xv and 380 pages. $1.25 *net*.

Manual of Astronomy. By Charles A. Young. Ginn & Co., Boston. 1902. vii and 611 pages. $2.25.

Elementary Zoölogy. 2nd Edition, Revised. By Vernon L. Kellogg. Henry Holt & Co., New York. 1902. xv and 484 pages. $1.20 *net*.

Life and Health. By Albert F. Blaisdell. Ginn & Co., Boston. 1902. vi and 346 pages. 90 cents.

Reports of Meetings.

STATE SCIENCE TEACHERS' ASSOCIATION OF INDIANA.

The seventh annual session of the association was held in Indianapolis April 25 and 26. The program was of definite value to the teachers of the various sciences.

The special object of each paper was to describe methods used and results obtained by the author in his class work.

The discussion following each paper was animated. Everyone pronounced the meeting a success.

Reported by D. T. Weir.

CENTRAL ASSOCIATION OF PHYSICS TEACHERS.

At a meeting of the physics teachers of about a dozen schools in the spring of 1902, a committee was appointed to ascertain the feasibility of organizing an association among the teachers of physics of the Central States. The responses to nearly five hundred circulars sent out were so heartily in favor of such an association that a meeting was held at Chicago on June 7, 1902, for the purpose of effecting a formal organization. At this meeting, representatives from twenty-five schools being present, a constitution was adopted and the following officers elected:

President, Chas. H. Smith, Hyde Park High School, Chicago.

First Vice-President, Franklin H. Ayres, Central High School, Kansas City, Mo.

Second Vice-President, C. F. Adams, Central High School, Detroit, Mich.

Secretary, C. E. Linebarger, Lake View High School, Chicago.

Treasurer, E. C. Woodruff, Lyons Township High School, La Grange, Ill.

Much enthusiasm was exhibited at the meeting and it was the firm belief of those present that great good would result from such an organization. It was decided to hold a meeting the Friday and Saturday following Thanksgiving and also one during the spring vacation. The features of the meetings are to be (1) an address by an advanced teacher and investigator in the field of physics, (2) short papers and discussions on practical experiences in teaching, (3) visits to laboratories and manufacturing plants, (4) exhibitions of physics apparatus by dealers and manufacturers, (5) informal banquet, Friday evening.

N. E. A. ROUND TABLE CONFERENCE IN PHYSICAL SCIENCE.

MINNEAPOLIS, MINN., JULY 9, 1902.

Mr. W. A. Fiske, Richmond (Ind.) High School, *Leader.*

[The following program had been sent about the first of June to quite a number of different teachers and science men of the country, and it was also distributed among the audience at the Wednesday session of the Department of Science Instruction, which immediately preceded the Conference.]

PHYSICS.

1. Proportional amount of time in a one year's course in Physics, to be given to the following subjects:
   (a) Mechanics, (b) Heat, (c) Sound, (d) Light, (e) Magnetism, (f) Electricity.
2. Relative amount of time given to
   (a) Laboratory Work, (b Lectures, (c) Recitation, (d) Reviews, (e) Examination.
3. Laboratory Experiments:
   (a) Nature, (b) Selection, (c) Number Required, (d) Educational Value.
4. Qualitative Experiments:
   (a) Place, (b) Purpose, (c) Importance, (d) Number, (e) Value.
5. First Appropriation:
   (a) How Invested? (b) By Whom?

CHEMISTRY.

1. Theoretical Chemistry:
   (a) When Presented, (b) How Much? (c) How Approached, by experiment or dogma? (d) How Utilized? (e) Shall Recent Theories be Taught?
2. Qualitative Analysis in High School course:
   (a) Time Devoted to It; (b) Importance Placed Upon It; (c) Educational Value.
3. Best methods of presenting to beginners the laws of Chemical Combinations and the Atomic Theory.
4. Symbols and Equations:
   (a) Time of Introduction; (b) To What Extent Used? (c) Value Derived by Pupil.
5. Difficulties, how met?
   (a) Inaccuracies, (b) Lack of Chemical Imagination, (c) Drawing Wrong Conclusions, (d) Delaying Records, (e) Borrowing or Cheating.

PHYSICS AND CHEMISTRY.

1. Historical method in Elementary Science:
   (a) What Should be Presented? (b) Where and How Obtained? (c) Amount Presented? (d) Value to Pupil?
2. Supervision of Laboratory Work:
   (a) Relation of Teacher to Pupil During Working Period; (b) Economy of Pupil's Time in Writing Laboratory Notes; (c) How to Obtain a Strict Scientific Interest; (d) Time Given to Note Book Inspection, Quiz and Problem Work.
3. The Laboratory Note Book:
   (a) Attitude of Pupil Toward It; (b) Form of Book to Use; (c) Best Arrangement of Data; (d) Time and Place of Making Record; (e) Educational Value.
4. The Science Library:
   (a) Location? (b) How and When Used? (c) Value to Pupil.

5. Closer Correlation between the Science and English Work:
   (a) Desirability? (b) How Best Obtained?

6. Value of Nature Study in the Grades to High School Science.

MR. FISKE: I see, in looking over the report of last year's conference, that we closed about half past six o'clock. We haven't much time left us, but I hope our interest in the subjects on this program is such that we can at least spend an hour in their discussion. We have given to quite a number the program that has been prepared for this occasion. I have been asked by at least two or three science papers of the United States to furnish a report of this conference, and if any one who takes part in the discussion this evening wishes to have his discussions revised, such may be indicated at the close of the meeting. I have anticipated the shortness of the time and therefore concluded as an introduction to this subject, to take up only a few moments of time and present two or three phases very interesting to me relating to *Physical Science in the High School.*

Physical science as we find it today in secondary schools is the result of a steady evolution. A quarter of a century ago it was taught mostly in a didactic manner, with no thought of a laboratory and with but little experimental work in the lecture room.

The illustrations of the text were examined and carefully discussed, which was, in most cases, about the extent of the apparatus used. Later, when apparatus became cheaper and was more accessible to the average school, experimental work for illustrative purposes was made a part of the daily recitation. Finally, the laboratory was introduced, which added a decided interest to the work and made it much more valuable to the pupil.

All experimental work was at first qualitative in its nature, and inductive methods of presentation were largely employed by those having the work in charge. Recently an inductive text book has been considered out of date, and to maintain its place in the field, of necessity has undergone a careful revision.

Thus we see that the methods of presenting these subjects, and even the tools in many cases, with which the work is done are not fixed, but are subject to wide variations upon the inception of new ideas. That is why we meet here today for the purpose of discussing these subjects in their various phases and obtaining the best each one has to bring.

The relation which the physical sciences bear to certain other subjects of the curriculum is one of extreme interest. As the most important of these, mathematics, English and drawing may be named.

There was a time when physics and chemistry, instead of being mathematical, as at present, were more philosophical. The problem was but little known while much time was spent in reasoning upon obvious natural

phenomena. It is not so now. The text book on these subjects, especially physics, that is not rigidly mathematical is looked upon with some doubt as being the proper one to use in the upper classes of our secondary schools.

In view of this condition of things, it is of advantage that the department of mathematics recognize the needs of pupils beginning the subject of physics. The hare-and-hound style of problems in algebra is in a measure being displaced by those of a more practical value—by instruction and drill upon principles that will be of far more advantage further on in the course.

It frequently happens that a pupil having three terms of algebra and one or more of geometry is tripped up on the solution of a simple equation in the subject of physics. This, however, is not a fault of the mathematics teacher any more than of the teacher of physics. The fault, we believe, lies in the fact that the pupil is permitted to regard the subjects of mathematics and physics as two separate and distinct things with no relation whatever existing between them.

The pupil has finished his mathematics, as he thinks, and begins the subject of physics, to him a new field, little thinking he can use the old tools to continue his work.

The same close relation should exist between the departments of English and drawing, because of the great value of each to the work in physics, while the latter may be made most helpful to the work of these two departments.

There seems to be a growing tendency in some schools to make the work easy, as it is called. A teacher the other day said: "I have one child and if she passes in her work and has a good time while doing it I shall be satisfied." If "a good time" means a thorough entering into the spirit of the work, a high appreciation of all the school is able to give and a proper bearing under its rules and regulations, the statement may be an appropriate one; but if the ordinary meaning of "a good time" is understood, this, then, is certainly not the proper attitude to take. It vitiates the school and inculcates in the mind of the child improper notions of life. The school is not the place to have a good time, but a place where one may come up against difficult things. The work should have enough of severity about it to command the highest respect of the pupil and at the same time should be made so interesting and attractive by the teacher that it will be a pleasant rather than an irksome task.

A few, it is true, do fall by the wayside, but such results, upon investigation, are nearly always found to be due to outside disturbances rather than to good, wholesome and well regulated study.

The work of physics and chemistry then should be made difficult. It should mean something. The laboratory should be made a place of good

substantial results, and not a place of amusement. To this end the work, especially in physics, should be purely quantitative in its nature, in which case the pupil will have greater respect for what he is doing, and will find greater pleasure in it because of the definite result he is able to obtain.

The voluminous condition of the majority of text books is a problem with which the teacher has to deal, and unless a judicious pruning is resorted to, the work cannot be efficiently done. This is especially true where one-third to one-half of the time is devoted to laboratory work. An attempt to cover too much ground in one year, either in the laboratory or class room, is, we believe, a serious fault and one which results in many bad habits on the part of the pupil. The work is poorly done; much of it is unfinished and unmastered; the pupil fails to appreciate the importance of the subject and falls far short of one of its prime purposes—the development of a scientific attitude of mind. The aim, we believe, should be to spend the time allotted to a given subject upon the most important parts of the text and then use all possible means to have the pupil appreciate and master the work assigned him. What these most important parts are, is involved in the first question for discussion this afternoon—the proportional amount of time in a one year's course in physics, to be given to the following subjects: Mechanics, Heat, Sound, Light, Magnetism and Electricity.

There was a time when I felt that the greater portion of the school year should be spent upon Electricity, but I do not think that way now. I do not know what others think, but it seems to me that the best results, from my own observation, are obtained from a careful study of Mechanics and Heat; therefore, it might be well to spend at least half of the time upon these two subjects, a fourth of the time given to a thorough consideration of the general principles of Sound and Light, and perhaps about as much time on Electricity as upon those two.

We will now leave the first subject open for discussion, and during the discussion if it is the desire of anyone to take up some other topic, that may be done.

Mr. Willis E. Tower, Englewood High School, Chicago: I am very sorry our time is short, but I agree with our chairman that Mechanics and Heat should occupy half the time, but I am not quite ready, however, to give Electricity any less time than is given to Sound and Light. I cannot discuss this outline as I would like to, as I am sure it would interfere with what others would have to say. I would like, therefore, instead of discussing it to make an announcement which will doubtless not be news to a good many who are present, and that is that there was formed last month a Central Association of Physics Teachers, along the line of the Eastern Association of Physics Teachers. Many of you doubtless know of this and perhaps some of you were present at its formation. And some of you are familiar with the magazine, School Science. The

editor of SCHOOL SCIENCE is the secretary of the association, and its president is Chas. H. Smith of Hyde Park High School, Chicago. Its first regular meeting is to be held next Thanksgiving vacation at the Lewis Institute, Chicago, and among the speakers will be Prof. Carhart of the University of Michigan. I believe this Central Association of Physics Teachers will be of great assistance to physics teachers in secondary schools and colleges in getting together along the right lines of physics teaching.

MR. F. L. BARKER, Chemistry, Duluth: There is one thing here in chemistry I would like to speak of and that is Qualitative Anaylsis in the High School Course; and I would like to raise a protest against teaching qualitative analysis in the high school. It seems to me it is entirely out of place. In the first place, we can't teach very much of it; and in the second place, to those who are going to college it will do no good, for they will immediately have to take the work all over that we have given them and those who are not going to college cannot get enough to amount to anything. In many of our states we have large mining interests. The development of these and the chemical problems that confront the mining engineer or the pupil who has any interest whatever in mining work are of prime importance to that pupil; and that teacher who is so situated that he can teach to pupils in a mining country has an opportunity not to be neglected for practical work along the lines that are of great importance to that pupil. On the other hand, if one is teaching in a manufacturing country, there is a great field open for manufacturing chemistry and the practical application of chemicals to everyday life. Enough work can be given to cover two or three years of general chemistry, with all of the practical applications you might make. We hear a great deal of industrial education, but it seems to me that the man who is teaching chemistry has the best chance in the world to give industrial application.

I just want to raise this protest against qualitative analysis in the high-school course.

MISS JESSIE F. CAPLIN, Chemistry, Minneapolis, Minn.: There is one statement about qualitative analysis that I would like to speak of. You say the pupils must take the work over if they go to college. If we give them a proportion of the whole year in chemistry they must take the whole year over again in the academic course. My experience has been (and I send perhaps 90 and perhaps 150 of my pupils over to the university) with the qualitative analysis first that the general chemistry is a great deal stronger because they have had chemistry before. Of course we can't cover it. Of course we can't take anything but the simplest reactions; but that makes the work that much easier—that much less that they have to do when they get to the university; and therefore, they can expend that much more strength on the harder reactions, it seems to me.

Miss Clara Struble, Physics, Bismarck, N. D.: I would like to have someone answer the questions involved in 2, 3 and 4.

Mr. Fiske: The nature of laboratory experiments, I am convinced from experience, should be quantitative. There may be a few qualitative experiments introduced, but there is not that opportunity for thought on the part of the pupil obtained from qualitative experiments in the laboratory. The time in the class room, according to my notion of the matter, should be partly taken up with qualitative experiments to illustrate the work. The number of laboratory experiments required should perhaps be as many as 35 or 40 during the year. If this number of good quantitative experiments in the laboratory is worked by the pupil during the year, pretty fair work in that subject is being done.

Some people do not believe very much in reviews. That may be true with older pupils, but with younger pupils it is well to review some. As far as examinations are concerned, I hardly ever give any. I take, in a measure, my knowledge of the ability of the pupil. I try to impress upon the pupil's mind that his interest and enthusiasm in the work are the main factors upon which I depend, occasionally giving a test on some particular phase of the subject. But what we call real, old-fashioned examinations, I haven't much sympathy with.

Q. You say you give no tests or examinations. Do you attach any importance whatever to the mathematical problems in connection with these different subjects?

Mr. Fiske: Yes, very much. The subject is very nearly all mathematical. As I stated before, modern text books, or at least the best ones (I think I am not wrong on this) are very mathematical, and that is the kind of text book I believe in. But to set aside a certain time at the end of the month or at the end of six months or at the end of the year for a good long, stiff examination to cover the whole subject, I do not think, the better plan.

Mr. H. A. Bbitzius, Physics, C. H. S., Minneapolis, Minn.: I would like to have a little bit more information in reference to the time to be given to laboratory and recitation work; and to bring up the subject, I am willing to state about the time given in Minneapolis. As far as laboratory work and the recitation work are concerned, we try to divide the work equally. Now, then, as to lectures. It has been my aim to have the pupils feel that after they have completed a recitation they should be frank enough to admit that they did not understand the subject; and right in that connection is where I aim to get in my lecture work.

Then as to reviews. While I believe in reviews, I find that my time is so limited that I cannot give much of it to reviews, but then I believe in taking tests and then the student is obliged to cover a specific part of the work we have gone over and be prepared on anything that may come up under that part of the subject; and my aim generally is to divide tests

up very much as they have been given here. And whenever they have completed that part of the subject I have them review the whole and come to me if they have any difficulty, but when the test is given, then they must be sure they understand the whole subject. Now I wish to say in connection with this that I do not believe in giving them credit on tests alone. I generally aim to have the recitation count for about half and the test for half—try to average them up—as my experience is that while some students seem to be bright in daily recitation, their memory is shorter than others and so when the test comes, unless they have very thoroughly prepared, I find they have forgotten some things. Some are good talkers to recite and others are good writers, and *vice versa*. So that is the plan we pursue very largely. Now then, I have stated this to get opinions from someone else.

Mr. F. E. Goodell (N. D. M. High), Des Moines, Iowa: There is one topic which has close connection with the one which we outline here. The examination has been spoken of. In this connection I would like to ask just what it should be, whether in the nature of questions or problems? My own practice is to include a large number of problems in these tests which I give. I believe in these things. I believe problems bring out principles and prevent that memory work which is the same in all science work. If the pupil can get the problem, he is almost sure to have the principle involved in that problem; he can't work it unless he has. So that in testing pupils' ability—the way in which they grasp the subject—I emphasize the problem and seek, as far as I can, to select such problems as will cover the subject most thoroughly and will bring out their grasp of the principles which it involves.

Q. Where should the qualitative work of physics come in?

Mr. Fiske: The place for qualitative experiments is certainly in the class room. Occasionally it is advisable, it seems to me, to work a quantitative experiment in the class room, but that can't be done very extensively because of the lack of time, but to illustrate the subject matter of the text, it is essential that this be the place for these experiments. It is true that the number of qualitative experiments cannot be very great because of the lack of time. It takes a long time in the class room to work very many experiments, and the average text book is so full of them that it is almost impossible to work all that are given, but the chief experiments in the text book and many that are not can be introduced to illustrate the subject under discussion.

Q. Did I understand you to say that the qualitative experiments should be worked chiefly in the class room and the laboratory experiments should be quantitative?

Mr. Fiske: That, I think, is the proper way.

(To be concluded in November.)

Correspondence.

EDITOR SCHOOL SCIENCE:

I have been interested in reading a recent article on "Magnetic Phantoms" in your paper. I have used a simple method, which I find very convenient and satisfactory. A piece of blue print paper is spread out over the magnet, and sprinkled with iron filings by means of a muslin bag. The entire apparatus is then placed in the sunshine for a few minutes, then the blue print washed in the usual manner. The method does not require a dark room, is fairly rapid, and well adapted to individual laboratory work.

B. G. SMITH.

Science Teacher, Corry (Pa.) High School.

EDITOR SCHOOL SCIENCE:

In a letter on the food value of alcohol, in the April number of SCHOOL SCIENCE, the writer seems to assume that we are obliged to admit the correctness of Professor Atwater's claim, that alcohol is a food. Is this true? Professor Atwater asserts that his experiments show that a certain amount of alcohol can be assimilated in the human body, and threfore concludes that it is a food. But Professor Atwater could not show that *all* of even a small amount of alcohol taken into the system could be assimilated. In fact, we are obliged to admit, not as the result of a few experiments, but as particularly proved by the experience of hundreds of thousands, that the larger part of the alcohol taken into the stomach, even in small amounts, acts as an irritant and a disturber of the normal functions. J. W. Long, M. D., in the Carolina Medical Journal, says: "Food warms the body; alcohol radiates more heat than it generates; alcohol increases nitrogenous metabolism, while food conserves the proteids. Food replaces tissue waste and adds to tissue growth; alcohol does neither. Food builds up, alcohol tears down. Food is nature's means to sustain life, alcohol is a protoplasm poison and destroys life. Food makes a normal man; alcohol makes him abnormal. Food does not produce degenerative changes, disease and death; alcohol does all, and more."

Let us remember, also, that Professor Atwater's conclusions have not been accepted by other great students of the question, but have rather been condemned by them .

HARRY CLIFFORD DOANE.

Grand Rapids, Mich.